NBSIR 76-1074

Operation Manual for 30,000 lbf Constant-Load Testing Machine

D. E. Marlowe and W. H. Appleton

Engineering Mechanics Section
Mechanics Division
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National Bureau of Standards
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Prepared for

NASA Langley Research Center
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U.S. DEPARTMENT OF COMMERCE, Elliot L. Richardson, *Secretary*
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Dr. Betsy Ancker-Johnson, *Assistant Secretary for Science and Technology*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Acting Director*

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OPERATION MANUAL FOR 30,000 lbf CONSTANT-LOAD TESTING MACHINE

Donald E. Marlowe

ABSTRACT

A 30,000 lbf (133 kN) constant-load testing machine has been designed, and ten of these machines have been delivered to the NASA Langley Research Center. Each machine is equipped with a self-contained, closed loop load controller which is maintained at a constant temperature, independent of the external ambient conditions.

Key Words: Creep; instrumentation; stress rupture; testing machine.

1. SCOPE

This manual presents the information necessary for the operation and maintenance of the 30,000 lbf (133 kN) constant-load testing machines (CLTM). Included are a general description of the machine, a description of the detailed operation of the machine components, and several associated schematics and tables.

2. GENERAL DESCRIPTION

The CLTM, shown in Figure 1, consists of three major subassemblies: a force measurement and control system, a force actuator, and a loading frame. A brief explanation of the function of each subassembly and its contribution to the overall system operation will be given here. Specific details of the operation of each will be found in its respective section later in this manual. Ten CLTM machines, shown in Figure 2, have been installed as a test system.

2.1 Force Measurement and Control System

The force measurement and control system includes a dual bridge load cell force transducer, a closed loop load controller to monitor and maintain load on the specimen, and a heater and temperature controller which maintains the transducer and controller at a constant temperature. This system is housed within the Instrumentation Module. A block diagram of the system is shown in Figure 3.

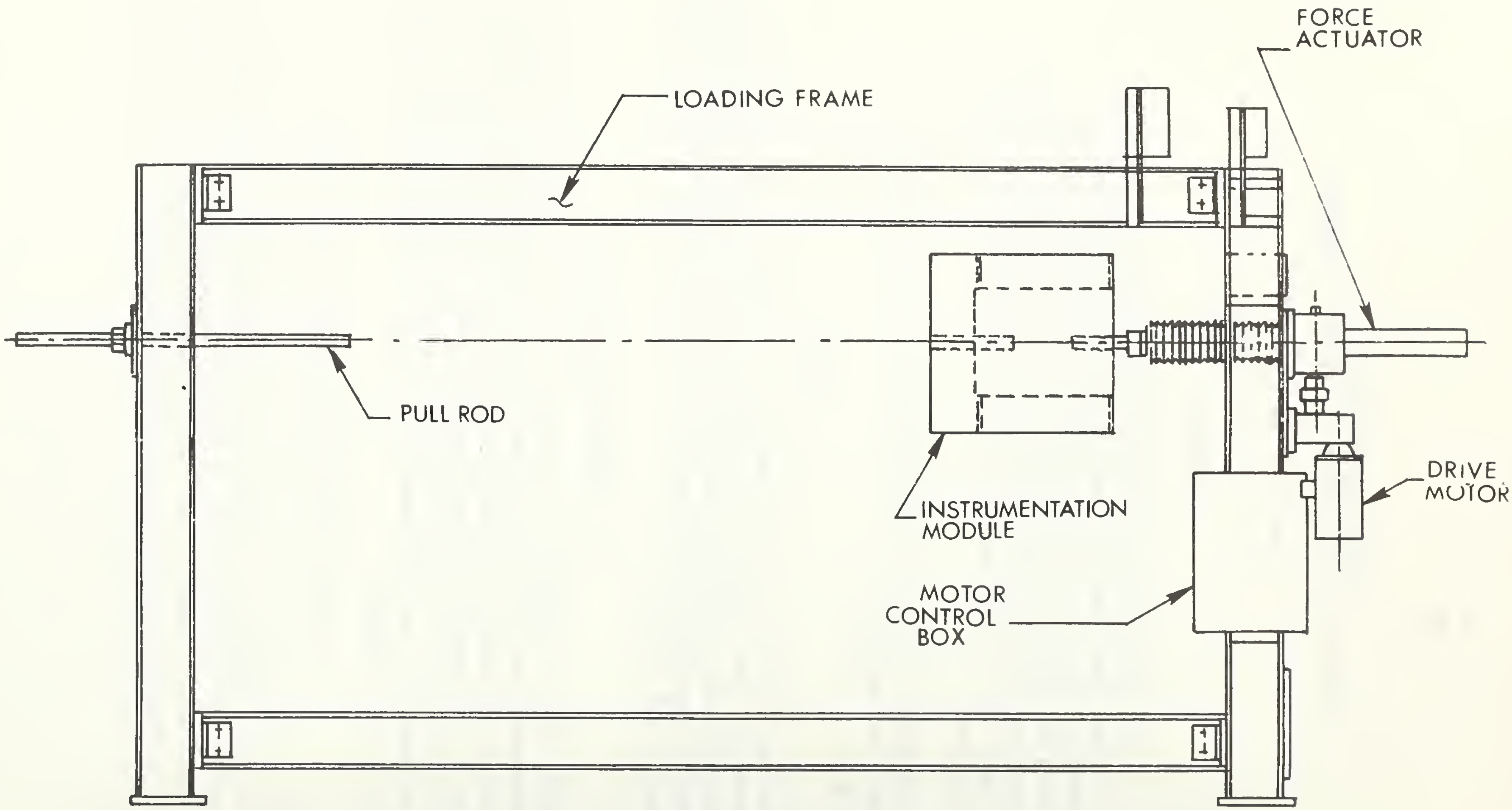

Figure 1 - Constant load testing machine.

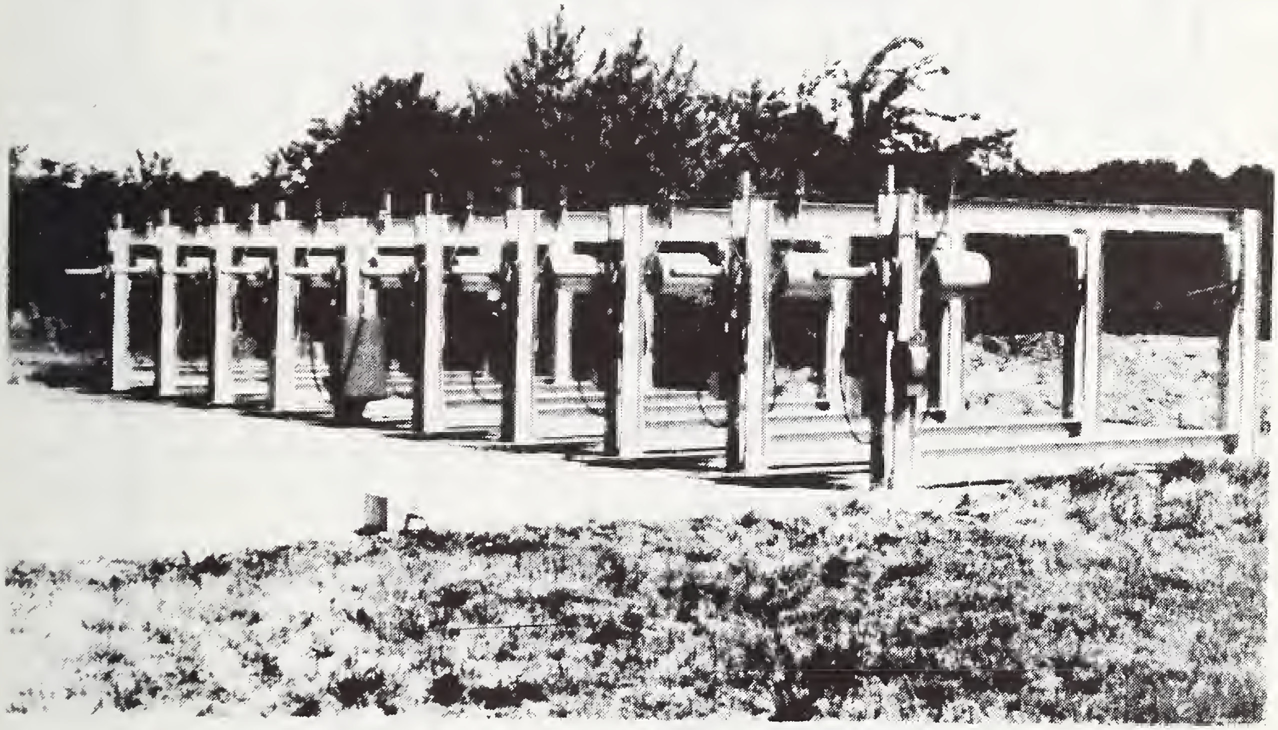

Figure 2 - Ten constant load testing machines - The CLTM's are numbered 1 through 10 from right to left.

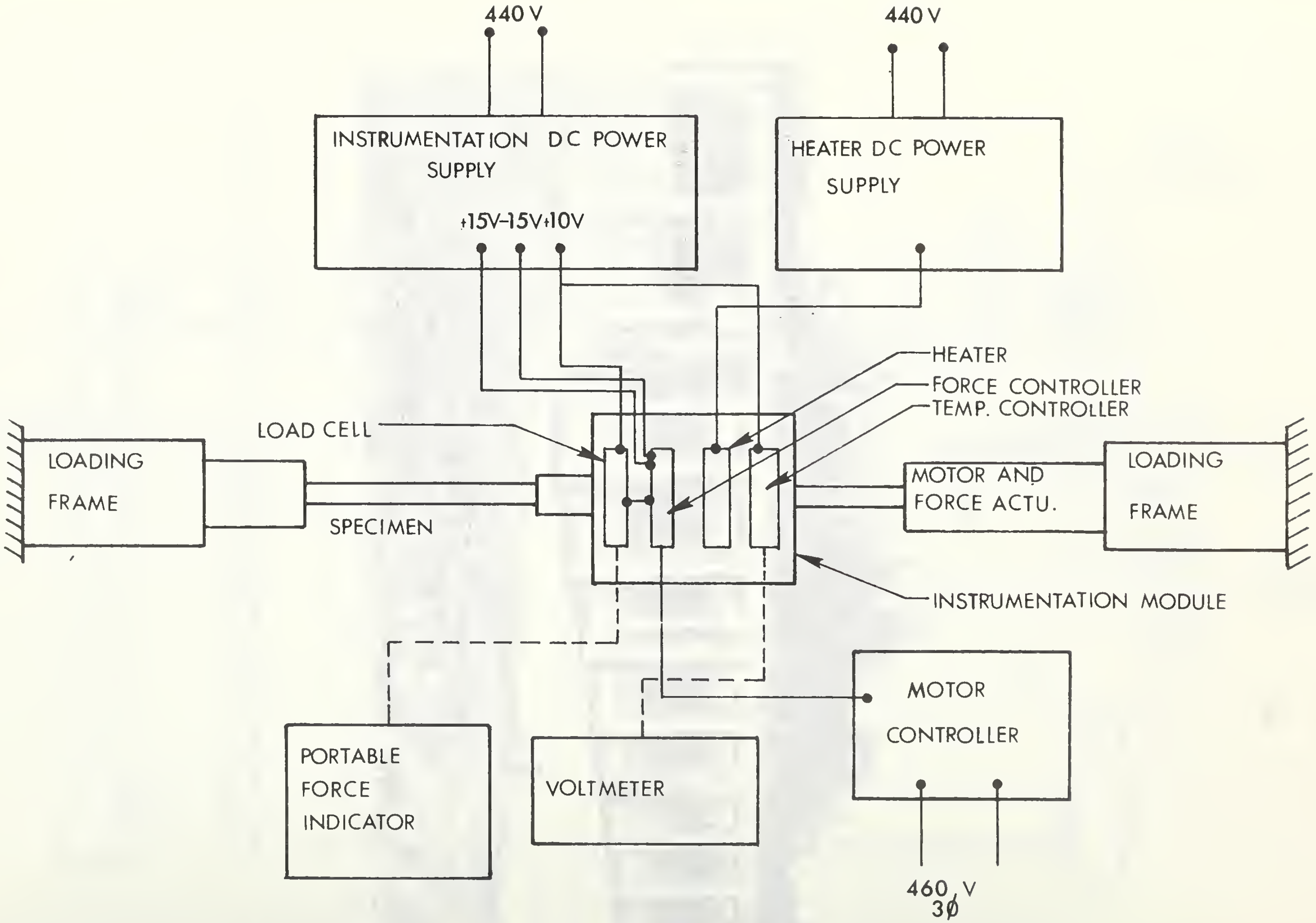

Figure 3 - Block diagram of force and temperature control systems.

One bridge of the dual bridge load cell is used to measure the load applied to the specimen. This load is indicated on the Portable Force Indicator provided with these machines. The output from the second bridge of the transducer is monitored in the load controller. The difference in the signals between the measured load and a preset load is displayed on the Null Meter in the Instrumentation Module. The machine acts to reduce the load error to within the preset deadband of the controller.

To provide the load cell and amplifier with a constant environment which is independent of the ambient conditions, a heater and temperature controller are contained within the Instrumentation Module. Heat is provided by three strip heaters distributed around the load cell. The temperature of the Instrumentation Module is maintained at about 50 °C (120 °F). This is achieved by supplying direct current power to the heater in varying amounts matching the heat energy loss of the Instrumentation Module. The Load Control-Temperature Control package is fixed to the load cell. Power supplied to the heaters varies from zero to approximately 250 watts as needed to maintain temperature.

2.2 Force Actuator

The force actuator in this machine is a screw jack driven by a 0.25 hp (190 W) reversible electric motor through a 3000:1 double-reduction worm gear. The total stroke for this system is 18 in (46 cm).

Initial specimen loading may be accomplished by manual operation of the actuator or by tightening the retaining nuts on the pull rod of the loading frame.

2.3 The Loading Frame

The loading frame for the CLTM is designed to resist specimen loads up to 30,000 lbf (133 kN). Each of the ten CLTM systems can operate independently or any combination of the ten machines can be operated together, as desired. The loading frame provides mounting support for the force actuator and the motor controller. The power supply for the load-control system is mounted on CLTM 6. A system power circuit breaker is mounted on CLTM 1.

3. THEORY OF OPERATION

A circuit diagram of the CLTM is shown in Figure 4. The load sensing transducer of the CLTM is a 50,000 lbf (220 kN) capacity load cell. The cell is instrumented with two similar strain gage bridges having a nominal rated output of 2 millivolts per volt (2mV/V).

The output of the secondary bridge (Bridge B) of the load cell is used to measure the load applied to the specimen. This measurement is made with the Portable Force Indicator provided with these machines. After the desired force has been applied to the specimen, as indicated by the secondary load cell bridge, the output of the primary bridge (Bridge A) is balanced against the output of the load controller. The difference between these signals is displayed on the Null Meter of the Instrumentation Module. Any change in load then appears on the meter as a deviation from the meter zero point. Meter deflection of a fixed amount, i.e., a load change of a fixed amount, causes operation of one of two optical switches. These control the motor circuit and the motor operates so as to reduce the error to within the desired limits. The bandwidth of allowed load change, which will not cause the motor to operate, is adjustable by changing the gain of the closed loop load controller.

Although the load cell is temperature compensated and a change in temperature will not significantly change its output, the amplifier of the closed loop controller must be maintained within somewhat tighter temperature limits. The temperature of the load cell and amplifier is maintained at approximately 50°C. To provide a heat stabalizing mass for the amplifier, it is clamped directly to the case of the load cell. Heat is supplied to the system through three strip heaters, each rated at 250 watts at 240 V, which are also clamped to the load cell.

The temperature is sensed by a thermistor Tc (Fig. 4) mounted in close proximity to the amplifier in the Instrumentation Module. A voltage divider formed by thermistor Tc and a variable resistor determine the current applied to the base of the power transistor in series with the heaters. This circuit supplies direct current power to the heater from zero to 150V, as needed to balance the heat loss of the Instrumentation Module. A second calibrated thermistor Tm is provided from which it is possible to monitor the temperature of the amplifier-temperature control package. This is accomplished by measuring the voltage between pins D and G of the connector on the outside of the Instrumentation Module. The resulting voltage equals the voltage drop across the monitor thermistor whose resistance changes with temperature.

4. OPERATIONAL CONTROLS AND INDICATORS

Operational controls and indicators for monitoring the operational status of the creep machine are listed below along with a description of their respective functions.

4.1 Force Measurement and Control System

The controls for this system are located on the end of the Instrumentation Module (Fig. 5). They are as follows:

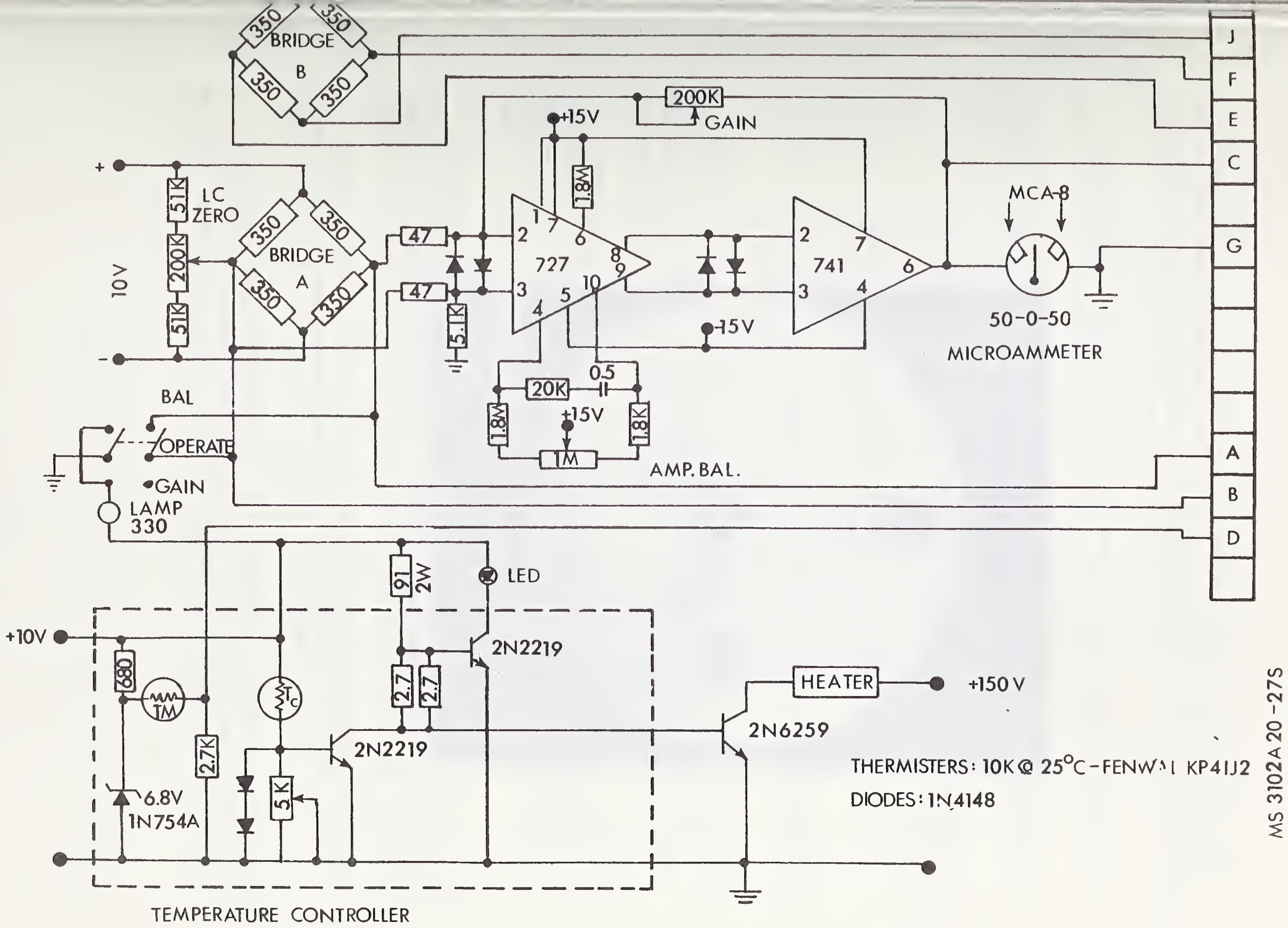

Figure 4 - Circuit diagram of CLTM Control System.

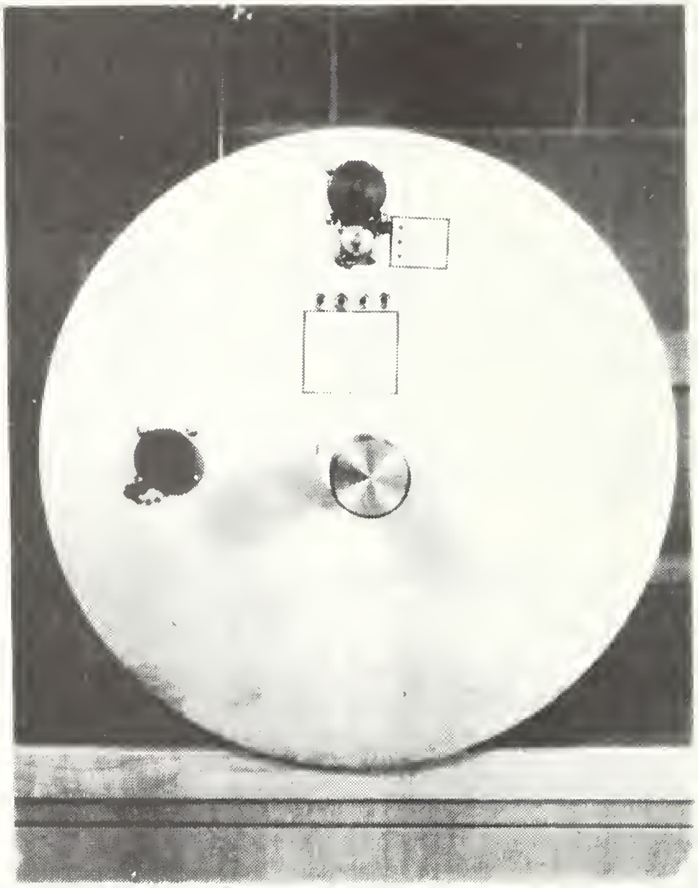

Figure 5 - Control panel of instrumentation module.

Null Meter. Located behind the weather tight cover on the left side of the panel, this is a multiple purpose micro-meter which, in conjunction with the position of the mode-selector switch, indicates the amplifier unbalance or the error from the set point.

Pilot Light. Visible in the null meter, this light indicates the flow of current to the heater circuit.

Balance-Operate-Gain Mode-Selector Switch. Located behind the weather tight cover at the top of the panel, this switch performs three functions:

1) Switch up-BALANCE. The amplifier input is shorted allowing the amplifier to be balanced: A light is lit for meter observation.

2) Switch center - OPERATE: The normal operating mode. The pilot pilot light shows heater operation.

3) Switch down - ADJUST: The system operates in a normal mode while the gain of the load control amplifier is set. A light is lit for null meter observation.

Gain. This potentiometer is used to adjust the gain of the closed loop force controller. This gain adjustment sets the width of the deadband of the motor controller, i.e., the load range about the load set point within which the load-maintainer will not operate.

Temperature. This potentiometer is used to adjust the temperature set-point of the controlled environment inside the Instrumentation Module. Clockwise rotation of the potentiometer increases the temperature. The pilot light visible on the null meter begins to glow when power is supplied to the strip heaters.

Load Cell Zero. The Load Cell Zero Potentiometer is used to balance the primary bridge of the force measurement circuit. After the desired load is applied to the specimen, the potentiometer is adjusted until the primary load cell circuit output is zero as indicated on the Null Meter.

AMP Balance. With the input to the amplifier shorted, this potentiometer is adjusted until the output of the amplifier is zero as indicated by the Null Meter.

Internal Function Connector. A connector is provided through which it is possible to monitor several of the internal systems of the Instrumentation Module. Those internal functions which may be monitored are as follows:

Pins	Functions
A and B	The electrical signal of the primary load cell bridge circuit.
C and G	Differential amplifier output signal.
D and G	Temperature.
E and F	Secondary load cell bridge output signal.
I and J	Secondary load cell bridge input voltage.

Pins E, F, I and J of this connector are in use when the Portable Load Indicator is employed to read the load applied to the specimen.

4.2 Motor Controller

The controls for this system are located on the starter box on the column of the CLTM. The controls for this system are as follows (Fig. 6):

ON-OFF. Applies 460 v, 3 phase operating power to the motor circuits housed inside the starter box.

HAND - OFF - AUTOMATIC. Selects the manual or automatic load-control mode for machine operation.

FORWARD - OFF - REVERSE. With the machine in manual mode, selects the direction of actuator travel.

RESET. Provides circuit breaker protection to the motor controller.

4.3 Portable Load Indicator

This instrument is used to read the load applied to the load cell. These measurements are made on the secondary bridge of the load cell. The controls for this instrument are described in the instruction manual for the instrument. However, as they relate to these creep machines, the controls function as follows (Fig. 7):

SPAN. The span setting for each load cell is 1.34 as shown in Table 1.

Balance. This adjustment provides initial bridge zero. The balance setting for zero bridge output under each test condition should be recorded at the beginning of each test.

Measure. This is the readout control for the instrument. It should be used in conjunction with the Null-Balance-Meter on the indicator to establish the force applied to the specimen.

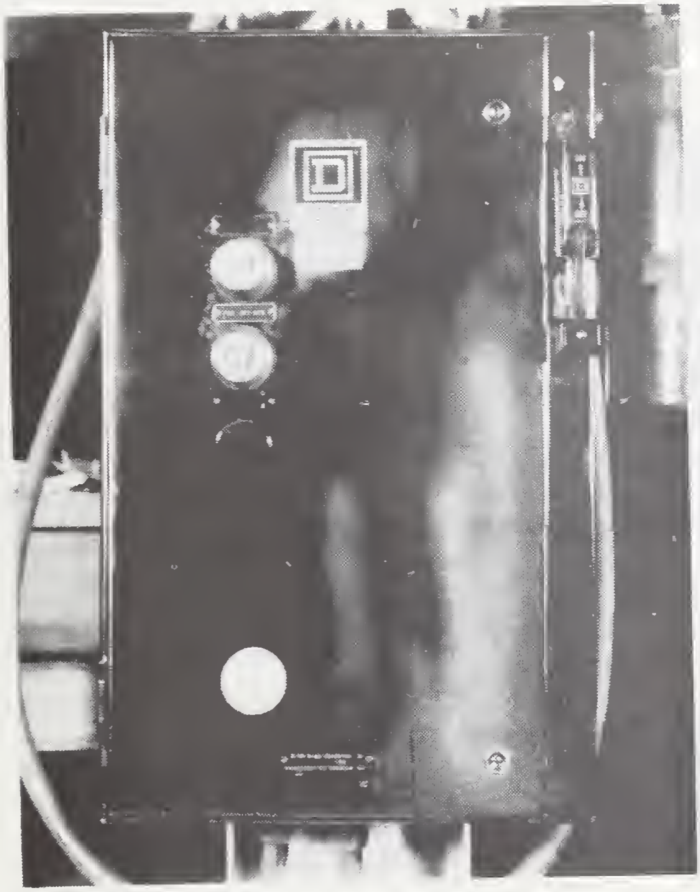

Figure 6 - Control panel of motor controller.

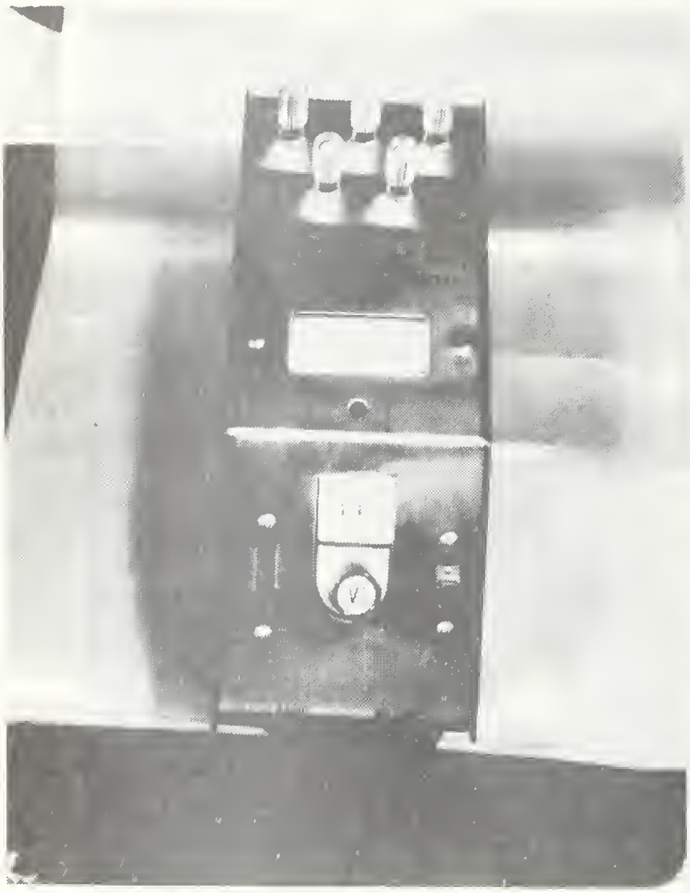

Figure 7 - Control panel of portable load indicator.

Table 1 - CLTM 1

TRANSDUCERS LOAD CELL NO. 59004-B VISHAY INDICATOR NBS 186836

CALIBRATED TO 30000 LBF TENSION APRIL 16, 1976

CALIBRATION IN ACCORDANCE WITH ASTM METHOD E 74-74

TENSION DATA FOR 23 DEGREES C

APPLIED LOAD IN LBF	DEFLECTIONS OBSERVED DURING CALIBRATION		DEVIATIONS FROM FITTED CURVE		VALUES FROM FITTED CURVE	CHANGE FROM PREVIOUS CALIBRATION
	RUN 1	RUN 2	RUN 1	RUN 2		
3000.	902.	905.	-8.	-5.	910.	
4000.	1202.	1206.	-5.	-1.	1207.	
6000.	1806.	1808.	2.	4.	1804.	
8000.	2401.	2406.	1.	6.	2400.	
10000.	3000.	3005.	2.	7.	2998.	
12000.	3606.	3604.	9.	7.	3597.	
14000.	4200.	4195.	4.	-1.	4196.	
16000.	4797.	4800.	1.	4.	4796.	
18000.	5391.	5390.	-6.	-7.	5397.	
20000.	5992.	5992.	-7.	-7.	5999.	
22000.	6594.	6598.	-7.	-3.	6601.	
24000.	7198.	7204.	-6.	-0.	7204.	
26000.	7810.	7812.	1.	3.	7809.	
28000.	8417.	8415.	3.	1.	8414.	
30000.	9023.	9022.	4.	3.	9019.	

STANDARDIZER READING = 1.34

NOTE - INITIAL NBS CALIBRATION, NO PREVIOUS DATA AVAILABLE FOR COMPARISON.

THE FOLLOWING CALIBRATION EQUATION, DESCRIBED IN SECTION 7.2 OF ASTM METHOD E 74-74, WAS FITTED TO THE CALIBRATION DATA BY THE METHOD OF LEAST SQUARES.

DEFLECTION = (A) + (B)(LOAD) + (C)(LOAD SQUARED)

WHERE A = .176161+02
B = .297051+00
C = .100098-06

UNCERTAINTY = 41.00 LBF

TENSION LOAD TABLE FOR 23 DEGREES C

DEFLECTION UNITS	LOAD LBF	INTERPOLATION TABLES UNITS	LBF	UNITS	LBF
1000.	3303.	100.	333.	10.	33.
2000.	6659.	200.	665.	20.	67.
3000.	10006.	300.	998.	30.	100.
4000.	13346.	400.	1330.	40.	133.
5000.	16679.	500.	1663.	50.	166.
6000.	20004.	600.	1995.	60.	200.
7000.	23322.	700.	2328.	70.	233.
8000.	26633.	800.	2660.	80.	266.
9000.	29937.	900.	2993.	90.	299.
10000.	33233.				

TRANSDUCERS LOAD CELL NO. 59003-8 VISHAY INDICATOR NBS 186836
CALIBRATED TO 30000 LBF TENSION APRIL 19,1976

CALIBRATION IN ACCORDANCE WITH ASTM METHOD E 74-74
TENSION DATA FOR 23 DEGREES C

APPLIED LOAD IN LBF	DEFLECTIONS OBSERVED DURING CALIBRATION RUN 1	RUN 2	DEVIATIONS FROM FITTED CURVE RUN 1	RUN 2	VALUES FROM FITTED CURVE	CHANGE FROM PREVIOUS CALIBRATION
3000.	897.	894.	-5.	-8.	902.	
4000.	1197.	1197.	-3.	-3.	1200.	
6000.	1803.	1804.	5.	6.	1798.	
8000.	2397.	2392.	1.	-4.	2396.	
10000.	3004.	3001.	10.	7.	2994.	
12000.	3602.	3602.	8.	8.	3594.	
14000.	4192.	4196.	-2.	2.	4194.	
16000.	4794.	4795.	-1.	-0.	4795.	
18000.	5391.	5395.	-6.	-2.	5397.	
20000.	5990.	5993.	-9.	-6.	5999.	
22000.	6599.	6596.	-4.	-7.	6603.	
24000.	7201.	7204.	-6.	-3.	7207.	
26000.	7820.	7822.	8.	10.	7812.	
28000.	8415.	8419.	-3.	1.	8418.	
30000.	9025.	9028.	1.	4.	9024.	

STANDARDIZER READING = 1.34
NOTE - INITIAL NBS CALIBRATION, NO PREVIOUS DATA AVAILABLE FOR COMPARISON.

THE FOLLOWING CALIBRATION EQUATION, DESCRIBED IN SECTION 7.2 OF ASTM METHOD E 74-74, WAS FITTED TO THE CALIBRATION DATA BY THE METHOD OF LEAST SQUARES.

DEFLECTION = (A) + (B)(LOAD) + (C)(LOAD SQUARED)

WHERE A = .840033+01
B = .297610+00
C = .971540-07

UNCERTAINTY = 48.00 LBF

TENSION LOAD TABLE FOR 23 DEGREES C

DEFLECTION UNITS	LOAD LBF	INTERPOLATION TABLES UNITS	LBF	UNITS	LBF
1000.	3328.	100.	332.	10.	33.
2000.	6677.	200.	664.	20.	66.
3000.	10019.	300.	996.	30.	100.
4000.	13354.	400.	1328.	40.	133.
5000.	16681.	500.	1660.	50.	166.
6000.	20002.	600.	1992.	60.	199.
7000.	23315.	700.	2324.	70.	232.
8000.	26621.	800.	2656.	80.	266.
9000.	29920.	900.	2988.	90.	299.
10000.	33213.				

Table 1 - CLTM 3

TRANSDUCERS LOAD CELL NO. 59002-B VISHAY INDICATOR NBS 186836
CALIBRATED TO 30000 LBF TENSION APRIL 24,1976

CALIBRATION IN ACCORDANCE WITH ASTM METHOD E 74-74
TENSION DATA FOR 23 DEGREES C

APPLIED LOAD IN LBF	DEFLECTIONS OBSERVED DURING CALIBRATION RUN 1	RUN 2	DEVIATIONS FROM FITTED CURVE RUN 1	RUN 2	VALUES FROM FITTED CURVE	CHANGE FROM PREVIOUS CALIBRATION
3000.	895.	890.	-1.	-6.	896.	
4000.	1188.	1189.	-6.	-5.	1194.	
6000.	1793.	1792.	4.	3.	1789.	
8000.	2391.	2389.	5.	3.	2386.	
10000.	2988.	2984.	6.	2.	2982.	
12000.	3590.	3582.	11.	3.	3579.	
14000.	4179.	4178.	2.	1.	4177.	
16000.	4780.	4777.	4.	1.	4776.	
18000.	5370.	5371.	-5.	-4.	5375.	
20000.	5967.	5966.	-8.	-9.	5975.	
22000.	6572.	6566.	-3.	-9.	6575.	
24000.	7178.	7175.	2.	-1.	7176.	
26000.	7781.	7776.	3.	-2.	7778.	
28000.	8383.	8381.	3.	1.	8380.	
30000.	8984.	8986.	2.	4.	8982.	

STANDARDIZER READING = 1.34

NOTE - INITIAL NBS CALIBRATION, NO PREVIOUS DATA AVAILABLE FOR COMPARISON.

THE FOLLOWING CALIBRATION EQUATION, DESCRIBED IN SECTION 7.2 OF ASTM METHOD E 74-74, WAS FITTED TO THE CALIBRATION DATA BY THE METHOD OF LEAST SQUARES.

DEFLECTION = (A) + (B)(LOAD) + (C)(LOAD SQUARED)

WHERE A = .485345+01
B = .296974+00
C = .759228-07

UNCERTAINTY = 40.00 LBF

TENSION LOAD TABLE FOR 23 DEGREES C

DEFLECTION UNITS	LOAD LBF	INTERPOLATION TABLES UNITS	LBF	UNITS	LBF
1000.	3348.	100.	334.	10.	33.
2000.	6707.	200.	667.	20.	67.
3000.	10060.	300.	1001.	30.	100.
4000.	13407.	400.	1334.	40.	133.
5000.	16748.	500.	1668.	50.	167.
6000.	20084.	600.	2002.	60.	200.
7000.	23415.	700.	2335.	70.	234.
8000.	26739.	800.	2669.	80.	267.
9000.	30058.	900.	3002.	90.	300.
10000.	33372.				

Table 1 – CLTM 4

TRANSDUCERS LOAD CELL NO. 59000-3 VISHAY INDICATOR NBS 186836
CALIBRATED TO 30000 LBF TENSION APRIL 14,1976

CALIBRATION IN ACCORDANCE WITH ASTM METHOD E 74-74
TENSION DATA FOR 23 DEGREES C

APPLIED LOAD IN LBF	DEFLECTIONS OBSERVED DURING CALIBRATION RUN 1	RUN 2	DEVIATIONS FROM FITTED CURVE RUN 1	RUN 2	VALUES FROM FITTED CURVE	CHANGE FROM PREVIOUS CALIBRATION
3000.	899.	900.	-5.	-4.	904.	
4000.	1200.	1200.	-2.	-2.	1202.	
6000.	1800.	1801.	2.	3.	1798.	
8000.	2393.	2393.	-2.	-2.	2395.	
10000.	2997.	2999.	4.	6.	2993.	
12000.	3600.	3600.	8.	8.	3592.	
14000.	4189.	4191.	-3.	-1.	4192.	
16000.	4793.	4798.	-0.	5.	4793.	
18000.	5391.	5393.	-4.	-2.	5395.	
20000.	5993.	5995.	-6.	-4.	5999.	
22000.	6597.	6598.	-6.	-5.	6603.	
24000.	7204.	7206.	-4.	-2.	7208.	
26000.	7820.	7818.	5.	3.	7815.	
28000.	8425.	8424.	3.	2.	8422.	
30000.	9031.	9032.	0.	1.	9031.	

STANDARDIZER READING = 1.34
NOTE - INITIAL NBS CALIBRATION, NO PREVIOUS DATA AVAILABLE FOR COMPARISON.

THE FOLLOWING CALIBRATION EQUATION, DESCRIBED IN SECTION 7.2 OF ASTM METHOD E 74-74, WAS FITTED TO THE CALIBRATION DATA BY THE METHOD OF LEAST SQUARES.

DEFLECTION = (A) + (B)(LOAD) + (C)(LOAD SQUARED)

WHERE A = .126366+02
B = .296711+00
C = .129528-06

UNCERTAINTY = 34.00 LBF

TENSION LOAD TABLE FOR 23 DEGREES C

DEFLECTION UNITS	LOAD LBF	INTERPOLATION TABLES UNITS	LBF	UNITS	LBF
1000.	3323.	100.	332.	10.	33.
2000.	6679.	200.	663.	20.	66.
3000.	10024.	300.	995.	30.	100.
4000.	13361.	400.	1327.	40.	133.
5000.	16687.	500.	1659.	50.	166.
6000.	20004.	600.	1990.	60.	199.
7000.	23312.	700.	2322.	70.	232.
8000.	26611.	800.	2654.	80.	265.
9000.	29900.	900.	2985.	90.	299.
10000.	33180.				

TRANSDUCERS LOAD CELL NO. 5900F-B VISHAY INDICATOR NBS 186836
CALIBRATED TO 30000 LBF TENSION APRIL 22, 1976

CALIBRATION IN ACCORDANCE WITH ASTM METHOD E 74-74
TENSION DATA FOR 23 DEGREES C

APPLIED LOAD IN LBF	DEFLECTIONS OBSERVED DURING CALIBRATION RUN 1	DEFLECTIONS OBSERVED DURING CALIBRATION RUN 2	DEVIATIONS FROM FITTED CURVE RUN 1	DEVIATIONS FROM FITTED CURVE RUN 2	VALUES FROM FITTED CURVE	CHANGE FROM PREVIOUS CALIBRATION
3000.	896.	895.	-5.	-6.	901.	
4000.	1197.	1190.	-0.	-7.	1197.	
6000.	1794.	1798.	3.	7.	1791.	
8000.	2385.	2387.	-0.	2.	2385.	
10000.	2981.	2992.	-0.	11.	2981.	
12000.	3582.	3588.	4.	10.	3578.	
14000.	4175.	4180.	-2.	3.	4177.	
16000.	4784.	4778.	8.	2.	4776.	
18000.	5374.	5366.	-3.	-11.	5377.	
20000.	5972.	5967.	-6.	-11.	5978.	
22000.	6570.	6581.	-11.	-0.	6581.	
24000.	7186.	7183.	0.	-3.	7186.	
26000.	7796.	7796.	5.	5.	7791.	
28000.	8397.	8399.	-0.	2.	8397.	
30000.	9008.	9007.	3.	2.	9005.	

STANDARDIZER READING = 1.34
NOTE - INITIAL NBS CALIBRATION, NO PREVIOUS DATA AVAILABLE FOR COMPARISON.

THE FOLLOWING CALIBRATION EQUATION, DESCRIBED IN SECTION 7.2 OF ASTM METHOD E 74-74, WAS FITTED TO THE CALIBRATION DATA BY THE METHOD OF LEAST SQUARES.

DEFLECTION = (A) + (B)(LOAD) + (C)(LOAD SQUARED)

WHERE A = .138762+02
B = .295260+00
C = .148282-06

UNCERTAINTY = 48.00 LBF

TENSION LOAD TABLE FOR 23 DEGREES C

DEFLECTION UNITS	LOAD LBF	INTERPOLATION TABLES UNITS	LBF	UNITS	LBF
1000.	3334.	100.	333.	10.	33.
2000.	6704.	200.	665.	20.	67.
3000.	10063.	300.	998.	30.	100.
4000.	13410.	400.	1330.	40.	133.
5000.	16746.	500.	1663.	50.	166.
6000.	20072.	600.	1995.	60.	200.
7000.	23386.	700.	2328.	70.	233.
8000.	26690.	800.	2660.	80.	266.
9000.	29983.	900.	2993.	90.	299.
10000.	33266.				

TRANSDUCERS LOAD CELL NO. 59007-B VISHAY INDICATOR NBS 186836
CALIBRATED TO 30000 LBF TENSION APRIL 20, 1976

CALIBRATION IN ACCORDANCE WITH ASTM METHOD E 74-74
TENSION DATA FOR 23 DEGREES C

APPLIED LOAD IN LBF	DEFLECTIONS OBSERVED DURING CALIBRATION RUN 1	DEFLECTIONS OBSERVED DURING CALIBRATION RUN 2	DEVIATIONS FROM FITTED CURVE RUN 1	DEVIATIONS FROM FITTED CURVE RUN 2	VALUES FROM FITTED CURVE	CHANGE FROM PREVIOUS CALIBRATION
3000.	910.	905.	-3.	-8.	913.	
4000.	1208.	1206.	-3.	-5.	1211.	
6000.	1814.	1811.	7.	4.	1807.	
8000.	2407.	2404.	2.	-1.	2405.	
10000.	3012.	3009.	9.	6.	3003.	
12000.	3605.	3607.	3.	5.	3602.	
14000.	4200.	4204.	-2.	2.	4202.	
16000.	4805.	4806.	2.	3.	4803.	
18000.	5402.	5403.	-3.	-2.	5405.	
20000.	6001.	6003.	-7.	-5.	6008.	
22000.	6603.	6605.	-8.	-6.	6611.	
24000.	7213.	7209.	-2.	-6.	7215.	
26000.	7828.	7830.	8.	10.	7820.	
28000.	8427.	8426.	1.	-0.	8426.	
30000.	9036.	9033.	3.	-0.	9033.	

STANDARDIZER READING = 1.34

NOTE - INITIAL NBS CALIBRATION, NO PREVIOUS DATA AVAILABLE FOR COMPARISON.

THE FOLLOWING CALIBRATION EQUATION, DESCRIBED IN SECTION 7.2 OF ASTM METHOD E 74-74, WAS FITTED TO THE CALIBRATION DATA BY THE METHOD OF LEAST SQUARES.

DEFLECTION = (A) + (B)(LOAD) + (C)(LOAD SQUARED)

WHERE A = .198301+02
B = .297289+00
C = .105133-06

UNCERTAINTY = 41.00 LBF

TENSION LOAD TABLE FOR 23 DEGREES C

DEFLECTION UNITS	LOAD LBF	INTERPOLATION TABLES UNITS	LBF	UNITS	LBF
1000.	3293.	100.	332.	10.	33.
2000.	6645.	200.	664.	20.	66.
3000.	9989.	300.	996.	30.	100.
4000.	13325.	400.	1328.	40.	133.
5000.	16654.	500.	1660.	50.	166.
6000.	19975.	600.	1992.	60.	199.
7000.	23288.	700.	2325.	70.	232.
8000.	26593.	800.	2657.	80.	266.
9000.	29891.	900.	2989.	90.	299.
10000.	33181.				

TRANSDUCERS LOAD CELL NO. 52998-B VISHAY INDICATOR NBS 186836
CALIBRATED TO 30000 LBF TENSION APRIL 19,1976

CALIBRATION IN ACCORDANCE WITH ASTM METHOD E 74-74
TENSION DATA FOR 23 DEGREES C

APPLIED LOAD IN LBF	DEFLECTIONS OBSERVED DURING CALIBRATION		DEVIATIONS FROM FITTED CURVE		VALUES FROM FITTED CURVE	CHANGE FROM PREVIOUS CALIBRATION
	RUN 1	RUN 2	RUN 1	RUN 2		
3000.	904.	903.	-5.	-6.	909.	
4000.	1206.	1203.	-2.	-5.	1208.	
6000.	1809.	1808.	4.	3.	1805.	
8000.	2404.	2403.	1.	-0.	2403.	
10000.	3011.	3009.	9.	7.	3002.	
12000.	3610.	3608.	9.	7.	3601.	
14000.	4204.	4200.	2.	-2.	4202.	
16000.	4807.	4804.	4.	1.	4803.	
18000.	5403.	5395.	-2.	-10.	5405.	
20000.	5996.	5996.	-11.	-11.	6007.	
22000.	6605.	6607.	-5.	-3.	6610.	
24000.	7213.	7210.	-1.	-4.	7214.	
26000.	7826.	7824.	7.	5.	7819.	
28000.	8431.	8424.	7.	-0.	8424.	
30000.	9030.	9032.	-0.	2.	9030.	

STANDARDIZER READING = 1.34

NOTE - INITIAL NBS CALIBRATION, NO PREVIOUS DATA AVAILABLE FOR COMPARISON.

THE FOLLOWING CALIBRATION EQUATION, DESCRIBED IN SECTION 7.2 OF ASTM METHOD E 74-74, WAS FITTED TO THE CALIBRATION DATA BY THE METHOD OF LEAST SQUARES.

DEFLECTION = (A) + (B)(LOAD) + (C)(LOAD SQUARED)

WHERE A = .152020+02
B = .297750+00
C = .920116-07

UNCERTAINTY = 46.00 LBF

TENSION LOAD TABLE FOR 23 DEGREES C

DEFLECTION UNITS	LOAD LBF	INTERPOLATION TABLES UNITS	LBF	UNITS	LBF
1000.	3304.	100.	332.	10.	33.
2000.	6652.	200.	664.	20.	66.
3000.	9994.	300.	996.	30.	100.
4000.	13328.	400.	1328.	40.	133.
5000.	16656.	500.	1660.	50.	166.
6000.	19977.	600.	1993.	60.	199.
7000.	23291.	700.	2325.	70.	232.
8000.	26599.	800.	2657.	80.	266.
9000.	29899.	900.	2989.	90.	299.
10000.	33194.				

Table 1 - CLTM 8

TRANSDUCERS LOAD CELL NO. 59001-5 VISHAY INDICATOR NBS 186836
CALIBRATED TO 30000 LBF TENSION APRIL 12,1976

CALIBRATION IN ACCORDANCE WITH ASTM METHOD E 74-74
TENSION DATA FOR 23 DEGREES C

APPLIED LOAD IN LBF	DEFLECTIONS OBSERVED DURING CALIBRATION RUN 1	RUN 2	DEVIATIONS FROM FITTED CURVE RUN 1	RUN 2	VALUES FROM FITTED CURVE	CHANGE FROM PREVIOUS CALIBRATION
3000.	894.	895.	-7.	-6.	901.	
4000.	1196.	1196.	-4.	-4.	1200.	
6000.	1801.	1798.	3.	-0.	1798.	
8000.	2401.	2400.	3.	2.	2398.	
10000.	3012.	3004.	14.	6.	2998.	
12000.	3607.	3608.	8.	9.	3599.	
14000.	4200.	4200.	-0.	-0.	4200.	
16000.	4804.	4806.	2.	4.	4802.	
18000.	5395.	5401.	-10.	-4.	5405.	
20000.	6000.	6001.	-9.	-8.	6009.	
22000.	6609.	6604.	-5.	-10.	6614.	
24000.	7219.	7215.	0.	-4.	7219.	
26000.	7829.	7829.	4.	4.	7825.	
28000.	8433.	8430.	2.	-1.	8431.	
30000.	9042.	9044.	3.	5.	9039.	

STANDARDIZER READING = 1.34

NOTE - INITIAL NBS CALIBRATION, NO PREVIOUS DATA AVAILABLE FOR COMPARISON.

THE FOLLOWING CALIBRATION EQUATION, DESCRIBED IN SECTION 7.2 OF ASTM METHOD E 74-74, WAS FITTED TO THE CALIBRATION DATA BY THE METHOD OF LEAST SQUARES.

DEFLECTION = (A) + (B)(LOAD) + (C)(LOAD SQUARED)

WHERE A = .479163+01
B = .298383+00
C = .915049-07

UNCERTAINTY = 49.00 LBF

TENSION LOAD TABLE FOR 23 DEGREES C

DEFLECTION UNITS	LOAD LBF	INTERPOLATION TABLES UNITS	LBF	UNITS	LBF
1000.	3332.	100.	331.	10.	33.
2000.	6673.	200.	663.	20.	66.
3000.	10007.	300.	994.	30.	99.
4000.	13335.	400.	1326.	40.	133.
5000.	16656.	500.	1657.	50.	166.
6000.	19970.	600.	1989.	60.	199.
7000.	23278.	700.	2320.	70.	232.
8000.	26578.	800.	2651.	80.	265.
9000.	29873.	900.	2983.	90.	298.
10000.	33161.				

Table 1 - CLTM 9

TRANSDUCERS LOAD CELL NO. 59006-B VISHAY INDICATOR NBS 186836

CALIBRATED TO 30000 LBF TENSION APRIL 21, 1976

CALIBRATION IN ACCORDANCE WITH ASTM METHOD E 74-74

TENSION DATA FOR 23 DEGREES C

APPLIED LOAD IN LBF	DEFLECTIONS OBSERVED DURING CALIBRATION		DEVIATIONS FROM FITTED CURVE		VALUES FROM FITTED CURVE	CHANGE FROM PREVIOUS CALIBRATION
	RUN 1	RUN 2	RUN 1	RUN 2		
3000.	903.	910.	-8.	-1.	911.	
4000.	1208.	1208.	-1.	-1.	1209.	
6000.	1812.	1811.	5.	4.	1807.	
8000.	2402.	2406.	-3.	1.	2405.	
10000.	3009.	3005.	4.	0.	3005.	
12000.	3608.	3612.	3.	7.	3605.	
14000.	4203.	4211.	-3.	5.	4206.	
16000.	4810.	4814.	3.	7.	4807.	
18000.	5404.	5410.	-6.	-0.	5410.	
20000.	6006.	6007.	-7.	-6.	6013.	
22000.	6612.	6613.	-6.	-5.	6618.	
24000.	7220.	7223.	-3.	0.	7223.	
26000.	7829.	7831.	1.	3.	7828.	
28000.	8439.	8439.	4.	4.	8435.	
30000.	9042.	9044.	-1.	1.	9043.	

STANDARDIZER READING = 1.34

NOTE - INITIAL NBS CALIBRATION, NO PREVIOUS DATA AVAILABLE FOR COMPARISON.

THE FOLLOWING CALIBRATION EQUATION, DESCRIBED IN SECTION 7.2 OF ASTM METHOD E 74-74, WAS FITTED TO THE CALIBRATION DATA BY THE METHOD OF LEAST SQUARES.

DEFLECTION = (A) + (B)(LOAD) + (C)(LOAD SQUARED)

WHERE A = .165937+02
B = .297793+00
C = .102431-06

UNCERTAINTY = 35.00 LBF

TENSION LOAD TABLE FOR 23 DEGREES C

DEFLECTION	LOAD	INTERPOLATION TABLES			
UNITS	LBF	UNITS	LBF	UNITS	LBF
1000.	3299.	100.	332.	10.	33.
2000.	6645.	200.	663.	20.	66.
3000.	9984.	300.	995.	30.	99.
4000.	13315.	400.	1327.	40.	133.
5000.	16639.	500.	1658.	50.	166.
6000.	19956.	600.	1990.	60.	199.
7000.	23264.	700.	2321.	70.	232.
8000.	26566.	800.	2653.	80.	265.
9000.	29860.	900.	2985.	90.	298.
10000.	33147.				

Table 1 - CLTM 10

TRANSDUCERS LOAD CELL NO. 58999-B VISHAY INDICATOR NBS 196836

CALIBRATED TO 30000 LBF TENSION APRIL 24,1976

CALIBRATION IN ACCORDANCE WITH ASTM METHOD E 74-74

TENSION DATA FOR 23 DEGREES C

APPLIED LOAD IN LBF	DEFLECTIONS OBSERVED DURING CALIBRATION RUN 1	RUN 2	DEVIATIONS FROM FITTED CURVE RUN 1	RUN 2	VALUES FROM FITTED CURVE	CHANGE FROM PREVIOUS CALIBRATION
3000.	888.	891.	-9.	-6.	897.	
4000.	1190.	1193.	-2.	1.	1192.	
6000.	1789.	1793.	5.	9.	1784.	
8000.	2372.	2377.	-5.	-0.	2377.	
10000.	2973.	2977.	2.	6.	2971.	
12000.	3577.	3573.	10.	6.	3567.	
14000.	4161.	4169.	-2.	6.	4163.	
16000.	4757.	4767.	-4.	6.	4761.	
18000.	5359.	5357.	-1.	-3.	5360.	
20000.	5958.	5953.	-3.	-8.	5961.	
22000.	6556.	6555.	-6.	-7.	6562.	
24000.	7156.	7165.	-9.	-0.	7165.	
26000.	7769.	7776.	-0.	7.	7769.	
28000.	8381.	8375.	6.	0.	8375.	
30000.	8985.	8983.	4.	2.	8981.	

STANDARDIZER READING = 1.34

NOTE - INITIAL NBS CALIBRATION, NO PREVIOUS DATA AVAILABLE FOR COMPARISON.

THE FOLLOWING CALIBRATION EQUATION, DESCRIBED IN SECTION 7.2 OF ASTM METHOD E 74-74, WAS FITTED TO THE CALIBRATION DATA BY THE METHOD OF LEAST SQUARES.

DEFLECTION = (A) + (B)(LOAD) + (C)(LOAD SQUARED)

WHERE A = .128265+02
B = .294280+00
C = .155834-06

UNCERTAINTY = 46.00 LBF

TENSION LOAD TABLE FOR 23 DEGREES C

DEFLECTION UNITS	LOAD LBF	INTERPOLATION TABLES UNITS	LBF	UNITS	LBF
1000.	3349.	100.	333.	10.	33.
2000.	6729.	200.	667.	20.	67.
3000.	10097.	300.	1000.	30.	100.
4000.	13453.	400.	1333.	40.	133.
5000.	16798.	500.	1666.	50.	167.
6000.	20131.	600.	2000.	60.	200.
7000.	23452.	700.	2333.	70.	233.
8000.	26762.	800.	2666.	80.	267.
9000.	30061.	900.	3000.	90.	300.
10000.	33349.				

On - Batt - Off. This 3-position slide switch is actuated to provide power to the measurement circuit.

5. OPERATION

This section provides the user with information on the start-up and operation procedures of the machine.

5.1 Establishing the Operating Temperature

To insure stable operation of the amplifier system after a period of machine shutdown, it is necessary to activate the temperature control system of the Instrumentation Module several hours before the machine will be used. The control temperature for this system is preset at approximately 50 °C. In addition to the internal temperature monitoring points at pins D and G of the connector, a copper-constantan thermocouple is attached to the internal electronics. This thermocouple is accessable under the cover of the small cable elbow on the Module.

1. Turn on the Power Disconnect Switch located on CLTM 1.

2. Turn on all power switches located inside the inboard junction box on the top of each machine being operated.

3. Adjust the voltage of the heater supply circuit to 150 V using the autotransformer located in the Power Supply Cabinet on CLTM 6.

4. Monitor the internal temperature of the Instrumentation Module by reading the voltage between pins D and G of the Internal Function Connector. A voltage of 3.1 V indicates that the internal temperature is 50 °C.

5. If temperature changes of the Module are desired, clockwise rotation of the Temperature Control raises the internal temperature. Refer to Figure 8 for the voltage at pins D and G corresponding to the internal temperature.

5.2 Applying the Force Level

This section describes the steps to be used in the initial application of load to the specimen.

1. Connect the Portable Transducer Indicator to the Internal Function Connector. Adjust the SPAN of the INDICATOR to the 1.34 value shown on Table 1. Adjust the BALANCE to null the meter. Record this balance value as noted in 4.3 above. Set the Indicator measurement dial to the value corresponding to the desired load on the specimen. (See the calibration chart provided for each module, Table 1).

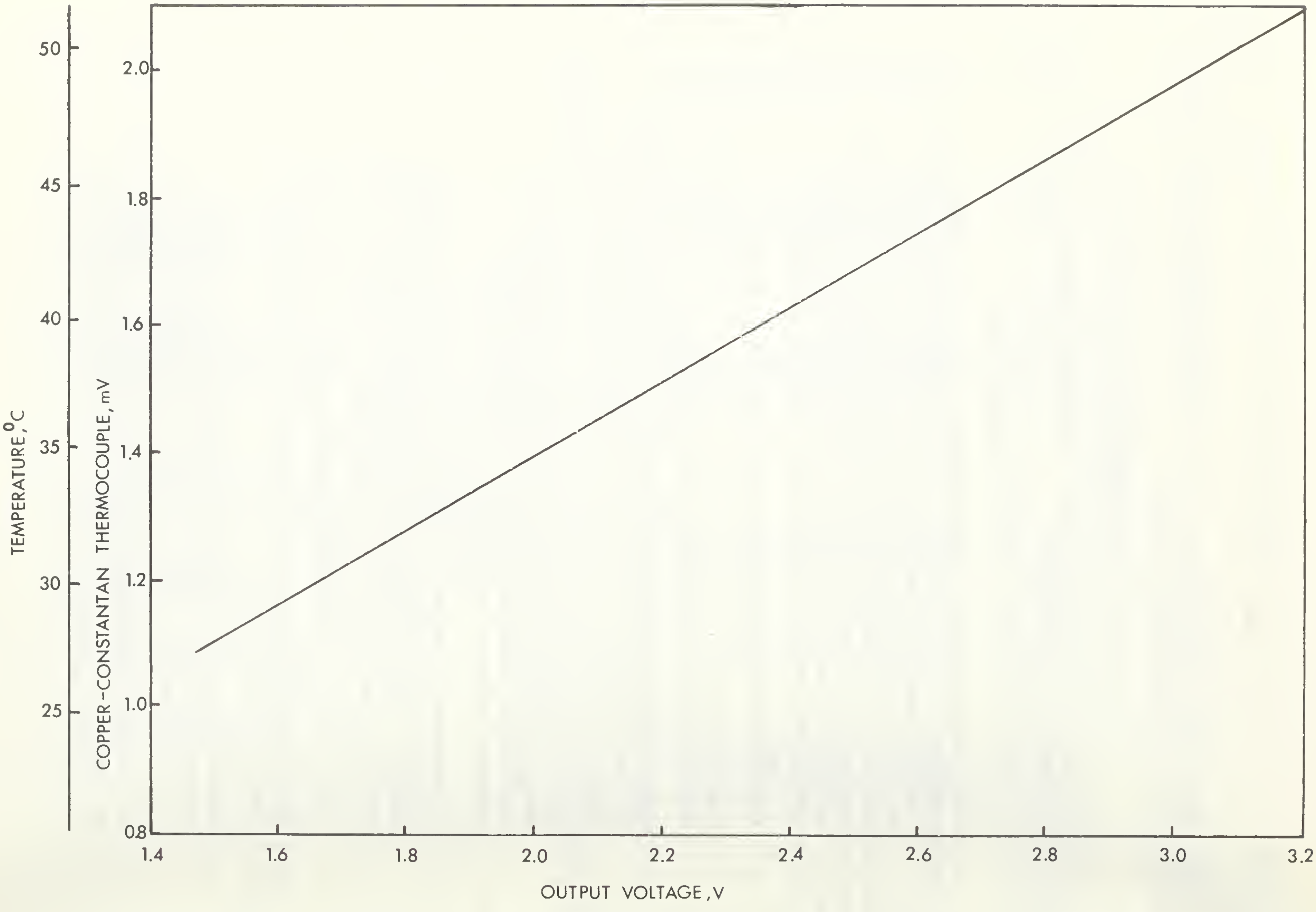

Figure 8 - Output voltage versus temperature at pins D and G.

2. Apply force to the specimen to null the Transducer Indicator meter. Three possible means of applying this force are suggested:

   a. Turn the adjusting nut of the pullrod where it passes through the loading frame (Fig. 1).

   b. Use a hollow ram jack, such as used to pretension concrete reinforcing bars, over the threaded pull rod to apply the initial load.

   c. Apply load using the creep machine motor in manual control. With the motor direction switch set to "forward", operate the motor while monitoring the transducer indicator. Care should be taken to prevent a load overshoot using this method. Because the actuator advances very slowly, it may be desirable to begin loading using method "a" above and finish using the motor in this manner.

5.3 Constant Load Operation

This section describes the setting of the controls for automatic operation of the load maintainer.

1. With the specimen at the desired load, set the Balance - Operate - Gain switch to "Balance". Adjust the "Amplifier Balance" control to null the output meter.

2. Set the Balance - Operate - Gain switch to "Gain". Adjust the "Load Cell Zero" control to null the output meter.

3. Set the Balance - Operate - Gain switch to "operate".

4. Set the Hand - Off - Auto switch on the motor controller to "Auto". The machine will now operate automatically and maintain load within the error bandwidth of the measurement system.

5. To monitor the load, connect the Portable Load Indicator to the load cell. Set the SPAN and BALANCE adjustments to the value determined at the time of calibration and recorded on Table 1 for each machine. Refer to Table 1 for the measured load.

5.4 Changing the Amplifier Gain

If it is necessary or becomes desirable to change the operating band of the load controller, the following steps should be followed.

1. With the amplifier balanced and load cell set as in Section 5.3, steps 1 and 2 above, and the Hand - Off - Auto switch in the HAND position, change the Indicator Measurement dial of the Portable Transducer Indicator by the amount of the desired bandwidth. For example, if the desired error bandwidth is +0.5 percent of capacity, add 150 lbf (670 N) to the load indicated on the portable instrument.

2. Increase (or decrease) the machine load to bring the Transducer Indicator into balance.

3. Adjust the GAIN control until the pointer of the Null Meter is at the plus (or minus) calibration mark (the small round mark on the dial face, Fig. 9).

4. Reset the force to the desired level.

5. Repeat the steps of Section 5.3 and 5.4 in succession until changes in the BALANCE do not affect the gain output.

5.5 General Notes

If stranded specimens, such as cable, are tested, provision should be made to prevent rotation of cable fittings. The Instrumentation Module must remain upright for proper operation.

The creep system has been designed to have some fail-safe features. Table 2 outlines some foreseeable events and their results.

Table 2 - Failure Events

Event	Result
Specimen Fails	Offscale meter deflection. Motor will not operate.
+15 V and -15 V power interrupted. or 10 V load cell excitation interrupted.	No meter deflection. Motor will not operate.
5 V power interrupted.	Temperature control and optical switch inoperative. Motor will not operate.
Heater power interrupted.	Temperature decreases causing amplifier output to change. Motor will run resulting in erroneous load.

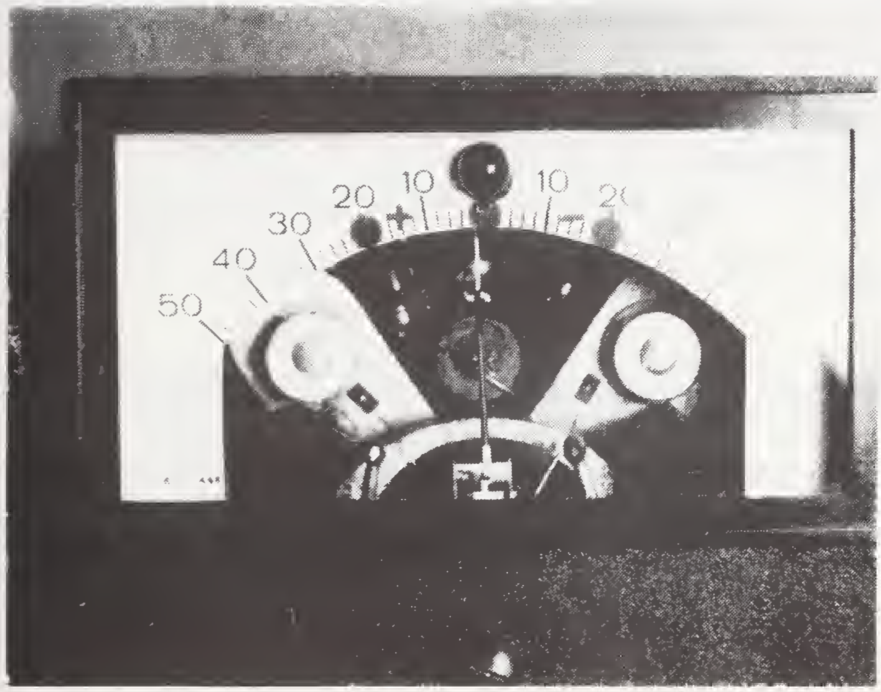

Figure 9 - Meter dial face.

NBS-114A (REV. 7-73)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBSIR 76-1074	2. Gov't Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE OPERATION MANUAL FOR 30,000 lbf CONSTANT-LOAD TESTING MACHINE	5. Publication Date October 1976
	6. Performing Organization Code
7. AUTHOR(S) Donald E. Marlowe	8. Performing Organ. Report No.
9. PERFORMING ORGANIZATION NAME AND ADDRESS NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234	10. Project/Task/Work Unit No. 2130544
	11. Contract/Grant No.
12. Sponsoring Organization Name and Complete Address *(Street, City, State, ZIP)* NASA Langley Research Center Hampton, Virginia	13. Type of Report & Period Covered
	14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

A 30,000 lbf (133 kN) constant-load testing machine has been designed, and ten of these machines have been delivered to the NASA Langley Research Center. Each machine is equipped with a self-contained, closed loop load controller which is maintained at a constant temperature, independent of the external ambient conditions.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Creep; instrumentation; stress rupture; testing machine.

18. AVAILABILITY [X] Unlimited	19. SECURITY CLASS (THIS REPORT) UNCLASSIFIED	21. NO. OF PAGES 30
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USCOMM-DC 29042-P74